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METAMORPHOSIS OF MUCIDAE

by

Charles Perez

Archives de Zoologie Experi. IV, pp 245-261 and 267-274.

GENERAL CONCLUSIONS

I have striven, in these researches, to elucidate for the organs -- with the exclusion of the nervous system and the heart -- the process of nymphalic transformations; to review and complete the results of the fundamental papers of Kowalevsky and Van Rees; to justify them versus the criticisms of Berlese directed at the phagocytic doctrine, and to discuss their opposing interpretations.

As far as the digestive tract is concerned, my current results confirm in all essential points the conclusions which I have formulated in connection with the ants. The phenomena revert to the general laws of epithelial renovation and more particularly of molting; the replacing cells are epithelial, sisters of exuviated cells; there is no intervention of foreign elements, migrating splanchnocytes or tracheal cells. In particular, the renovation of the middle intestine may be interpreted as the supppposition of two simultaneous moltings, followed by a special differentiation, which leads to the constitution of the new imaginal organ. For the anterior and posterior intestines, there likewise takes place a substitution of larval cells by imaginal cells, but this substitution, instead of being simultaneous, is slowly progressive. Since the original points of renovation are respectively restricted to two imaginal rings, their proliferation gives birth to an anterior nozzle which elongates toward the front; to a posterior nozzle which elongates toward the rear; and, gradually, the larval cells which have been driven back degenerate and, instead of being exuviated in the intestinal

lumen, are eliminated toward the general cavity and become the prey of phagocytes. In addition, at the two extremities of the digestive tube (Proboscis and rectal bulge) the renovation takes place in a centripetal direction, starting from the hypodermic histoblasts. Finally in the two sections, stomodeum and proctodeum, the renovation is not absolute, and on the contrary allows the survival of a certain number of larval cells.

In regard to the somatic muscles, a certain number of them completely disappear; this is the classical example of phagocytosis described by Kowalevsky and Van Rees. I have taken up again the study of this process and have described its details. I believe to have clearly established, contrary to Berlese's statements, that there indeed exists a leucocytic phagocytosis in the full meaning of the term, exhibiting all the characteristic stages: chimiotactic afflux of the leucocytes, infiltration of these ameboid elements in the as yet intact muscle, dislocation of the contractile substance into sarcolytes, the incorporation of these sarcolytes and finally, intracellular digestion of the inclusions in the phagocytes. There never does take place a spontaneous dislocation of the muscle; there are no sarcolytes freely disseminated in the blood; only the phagocytes which get dispersed once the incorporation [of sarcolytes] is finished, cast away in the general cavity the sarcolytic debris in the course of digestion, and the old degenerated muscular nuclei in pycnotic balls.

These satiated phagocytes constitute the sphere of granules (Kornchenkugeln of the German authors). Their dispersion in the general cavity is not at all the passive effect of a translation by an extremely slowed-down blood current. It is, on the contrary, the sign of a true amebcid activity which the incorporation of voluminous inclusions has perhaps made heavy but did not completely suppress. The manifest proof of this amebcism appears in the infiltration of spheres of granules within the most varied organs. When this penetration takes place in the imaginal organs (hypoderm in particular, muscles, rectal papillae, oviferous duct, folds of posterior intestine, etc.), its sole physiological meaning is that of a carrying of nutritive substances into tissues in proliferation. On the other hand when the infiltration takes place in the larval organs (salivary glands, hypoderm, tracheas, etc.), it provokes or accelerates the latter's dislocation, and it is followed by a new phagocytic activity. Despite the number and volume of muscular debris which feed them, the voracity of these phagocytes is not

satisfied, and one can see them further distending themselves by the enclosure of new material which is contrasted by its color from the sarcolytes in digestion and is easily recognized by the balls of degeneration lent to the ambient epithelium.

There results from this process a variety of shapes of spheres of granules, an extreme and often disconcerting chromatic polymorphism. Moreover, because of their disproportionately increased size, the spheres of granules are not all entirely comprised in the thickness of a section but, on the contrary, distributed in groups in several successive sections. It is to these two series of circumstances, without counting artificial tears, that one should attribute the erroneous interpretations of authors who thought to have found in these preparations masses of non-incorporated debris and who have believed to be able to conclude that a spontaneous dislocation or organs is taking place, a histolysis without phagocytosis. The procedure of smear preparation establishes in a conclusive manner that there are no other masses of debris than the spheres of granules, always containing a leucocytic nucleus. If one does not pay any attention to it, this weakly chromatic nucleus may be hidden by a voluminous opaque ball originating from an incorporated larval nucleus; it may be irregularly deformed between more resistant inclusions; but it is always present. In the well-made section, every time an accurate marking is possible, one finds it without exception in one of the successive groups of each sphere of granules. Always recognizable, it is the constant element that marks the morphological personality of spheres of granules: diverse disguises, so to speak, of identical leucocytic phagocytes.

A point particularly subject to discussion is the physiological state of cells captured by the phagocytes: are they attracted by the phagocytes when they are still fully intact or do they display visible signs of degeneration already before the arrival of the phagocytes; is there a prior intrinsic debilitation in which one may discover the very reason of their destruction by phagocytes? I have already examined this question at length in my paper on the ants, and Mercier has recently reopened the discussion on the subject. My present researches bring to light some new facts bearing on this point, and I must say right away that the answer to the above question is not at all an unequivocal one.

Thus, in the case of somatic muscles, the arrival of the phagocytes is extremely premature in a muscle which, histologically, is still completely normal; the manifested modifications are subsequent to the immigration of the phagocytes and one may consider them as the result of the mechanical dislocation, then of the intracellular digestion. My conclusions on this point, announced since 1904, have since been confirmed by Mercier. The facts are analogous in regard to the destruction of the larval abdominal hypoderm by the spheres of granules already charged with sarcolytes.

On the other hand, one notes in the epithelium of the anterior and posterior intestines, in the matrix of the posterior tracheas, an indisputable degeneration of the cells, and the phagocytes only intervene in the second instance, ingesting the cytoplasmic or nuclear balls which had been formed already without their intervention.

It is even possible that there are differences in this regard between the various cells of the same tissue. Thus, for the fatty cells, "phagocyted" in a premature manner, I find, contrary to mercier's observation, a penetration of phagocytes prior to the visible degeneration of the nucleus. For the fatty cells disappearing at the end of the nymphosis or even after the hatching (eclosion), the afflux of phagocytes and their fusion to the surface of the cell precedes by a long time the death of the latter. The cell, already encircled in a follicle of phagocytes, continues its normal functioning, and it is only after it has completed the resorption of its inclusions that it displays signs of decrepitation and that the phagocytosis is accomplished.

In an analogous manner, we have seen some cells to degenerate spontaneously into balls, at the extremity of a salivary gland, while normally the dislocation is subsequent to the infiltration of the spheres of granules.

It should be remarked, moreover, that the larval elements are sometimes subjected to mechanical modifications comparable to true traumatisms, and it is especially in these circumstances that one observes spontaneous degenerations. This is the case of the thoracic hypoderm, abruptly covered by an imaginal sheet, and thus thrown, en bloc, toward the cavity of the body, while in the abdomen the substitution takes place slowly and not all at once. This is, further, the case with fatty cells, rolled between the muscles and bursting under their pressure. And one may to some extent remember here also the overlapping of epithelial cells

resulting from the rapid contraction of the larval maw (jabot) or from the considerable shortening of the posterior intestine. In all these circumstances one may attribute to the mechanical causes a more or less preponderant part in the observed phenomena of degeneration.

As for the rest one should not forget that the question belongs to cellular physiology rather than to cytology. Certainly the functional state has its repercussions on the structure, but often a quite distant repercussion; the laws of correspondence escape us in this regard, and the present tools of histology are quite crude to be able to reveal the secret. It is quite certain that a subtle modification may be sufficient in determining the chimiotactic cell of the phagocytes at a time when this modification is not yet manifested by any visible alteration; above all it is a question of a quite stable protoplasmic edifice such as that of the striated muscular substance or rather of the inclusions of reserves such as those of the adipose tissue, elaborating products of the protoplasm and which no longer form an integral part of the latter.

On the other hand, the quite manifest structural modifications do not necessarily merit the term "pathological alteration," and are not indubitably the sign of a debilitation of the cell. Thus we have seen fat globules appearing in the cells of the large salivaries to be captured by phagocytes; but similar globules appear in the bud of the wing in the process of proliferation; and a little later these same larval cells display modification which may be interpreted as the end of a secretory activity, as well as the start of a degeneration. A better example is furnished perhaps by the Malpighian tubes which lose to a great extent their histological differentiation; one could believe that they would disappear, and if this really happened one would doubtless not hesitate to see in the disappearance of their brush-like edges, in the fading of their lumen, etc., unexceptional signs of a spontaneous degeneration. And, quite to the contrary, this is merely a transitory nymphal structure, starting from which the cells recuperate their differentiated structure when their functional activity resumes in the imago. The case of muscles is even more striking, due to the contrast present between identical elements, of which some persist while the others disappear. It is the "phagocyted" muscles which preserve their structure; the striation of the contractile substance is only obliterated during the course of digestion in the phagocytes. Others, on the contrary, lose their fibrillar constitution, their

striation, in a premature manner, and are transformed into homogeneous protoplasmic masses. Here it does indeed look as if a degeneration were present, but in fact these are homogeneous masses which, more or less altered by the addition of imaginal myoblasts, restore the striated muscles of the perfect insect. The homogeneous undifferentiated stage is not a pathological state but a normal stage of the transformation between two distinct differentiations.

We thus arrive at the concept that, in the phenomena of metamorphosis, the loss by a cell of its histological differentiation is not necessarily the sign of a pathological alteration. We are used, in the normal epigeneses, to seeing a cell starting out from an undifferentiated embryonic state, then specializing, little by little, into a definitive histological form; if this differentiation appears irreversible, isn't this perhaps because the cell takes its place, or in an irrevokable manner, in the physiological coordination of the organism? In metamorphosis the histological form appears to us more like the actual imprint of the particular function; and when, in the general commotion of the organism, the cell momentarily loses its special function and passes over to a slowed-down state of life, or lives in some way a banal life for its own sake, independently of its neighbors, it loses at the same time its differentiated structure; but it remains susceptible to a reaquisition, in the definitive organism, of an analogous differentiation at the same time that it resumes its particular place in the reestablished organism.

One can see how complex the question is. In any case what we can affirm is that there does not exist a general condition, simultaneously realized for all the cells of the same species, but on the contrary something personal to each cell is present which, at a given moment, determines its phagocytic destruction while the neighboring, quite analogous cells are preserved. And, in a general manner, the phenomena progress from the front to the back which, moreover, is a constant law of the development of segmented animals.

I have to return also to a point which I have already brought up in connection with the ants: How do the two main categories of phenomena which constitute metamorphosis, the histolysis of larval organs and histogenesis of imaginal organs, take place in time? The final organism takes the place of the larval organism by substitution, and the rather slow process of its histological differentiation is only

accomplished at the time of the burgeoning of the imago; on the other hand the histolytic destructions are quite rapid and take place during the first days of nymphosis. It would nevertheless be quite inexact to wish to subdivide the nymphal period into two phases: hystolysis and histogenesis, since one can say in a general fashion that the beginning of histogenesis precedes that of histolysis. Thus, for the digestive tract, the hypoderm, the tracheas, it is the imaginal cells which proliferate first, and it is before their progression that the larval cells degenerate and disappear; the very first phenomena of nymphosis are the rapid proliferation of scattered histoblasts in the body, and particularly of the buds of the head and the appendices; only in second place does the histolysis set in, and the adipose tissue furnishes us the interating example of an imaginal organ which attains its perfect state immediately after eclosion, when the larval organ which it replaces is still far from its final resorption. Thus what is taking place is not demolition followed by reconstruction but a progressive substitution; and the tissues in the process of destruction persist like guiding scaffolding until the disjointed histoblasts have made contact with each other in a final coordination system. I am convinced that this remark applies to all cases of metamorphosis; it shows how wrong one would be to consider these processes homologous to those of a cicatrization or a regeneration, and to compare the metamorphosis to an illness from which the organism recovers.

If one briefly examines that portion of the ensemble that persists, and the portion that disappears, one finds a general law which I have clearly formulated in my paper on the ants, and which I also consider valid, bestdes the insects, in all cases of metamorphosis. That which totally disappears are the most strictly specialized parts of the larva; they are simply ejected to the exterior like the chitin of the skeleton, where their substance is only utilized by the imaginal organism in a state of nourishment dissolved by a prior digestion. What is totally built up again are the most highly specialized parts of the imago, and it seems as if they could not have any other origin but the embryonic histoblasts which have remained undifferentiated up to the time of nymphosis, and undergoing at that time their first and last differentiation. In addition, a certain number of cells or organs persist in a more or less altered form, and are thus common to the larva and the imago. These are the least specialized elements, the least indissolubly linked to a determined coordination. They owe to this adaptative indifference the faculty of being able to take their

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places in two differing systems of physiological coordination. Thus for the digestive tube, the epithelium of the middle intestine is completely renewed by the pockets of embryonic cells; the larval maw is totally destroyed and an imaginal ring reconstitutes on an entirely different level a new maw and a new valve; the entire buccal region is likewise reconstituted; and by contrast, some larval cells persist in the middle portion of the esophagus, in the simple tubular communication between the specialized organs. The posterior intestine is the seat of entirely analogous phenomena.

Thus, further, in the tracheal system that which is most specialized, such as the large posterior stigmas and the main stems which end there, is destroyed by phagocytosis; a mass of new tracheas develops, by contrast, starting from the imaginal buds, and one sees, on the other hand, the persistence, with a more or less far-reaching alteration, of all those parts of the larval tracheal tree that may be reemployed in situ in the new canalization of the final organism.

The muscles furnish perhaps the most remarkable example. The muscles most particular to the maggot completely disappear by phagocytosis; the ones most particular to the fly reconstitute themselves completely at the expense of the mesoderm of the imaginal disks. And among these two extremes is interposed, for the persisting muscles, a whole series of gradations, with the importance of the role of the myoblasts in relation to the larval muscle varying to the very extent that the imaginal muscle deviates by its function from the larval muscle from which it derives: in the abdomen some muscles are hardly altered; the flight muscles, on the contrary, are altered to such an extent that their transformation is the equivalent of almost an entirely new construction of all pieces. One should also recall at this point the curious case of the intestinal muscles of which the myoplasm alone is "phagocyted," while the nucleated sarcoplasm persists and shows itself capable of a later regeneration of a new musculature.

Among the phenomena of persistence of larval organs, one of the most important ones is that of the Malpighian tubes. One would expect, it seems, a destruction of larval organs and a burgeoning of imaginal organs, such as takes place with other insects like the ants, where the metamorphosis is, nevertheless, on the whole much less intense than that of the flies. Now, quite to the contrary, the larval tubes pass to the imago almost unmodified after having gone

through an undifferentiated stage where their excretory function is suspended, supplemented during this time, as the case happens to be, by the accumulation of urates in the fatty body.

Another antinomy is exhibited precisely by this fatty body: given its function as an organ of reserve, one would believe it, a priori, to be capable of accomplishing this function as well in the imago as in the larva; this, moreover, is the case with the majority of insects and even of Diptera. The higher Diptera seem to be the only ones to possess a fatty body particular to the imago. And we have seen how the larval fatty body, persisting for a long time during nymphosis, exhibits this curious example of a larval organ whose final disappearance is only completed after the appearance of the perfect insect.

It is interesting to compare the organs of the larva and those of the imago also from another point of view whose importance I have already indicated in reference to the ants, that is, the relative size of cells. Sister cells issued of the same embryonic stock in fact develop in an entirely different manner. For the larval cells the multiplication stops even before the end of the embryonic period; their number is relatively reduced and they are sufficient for the growth of the larva without even dividing, but by becoming large themselves until attaining considerable proportions. The imaginal cells represented at the moment of the larval eclosion by a relatively small number of initial cells, and multiplying very little during larval life, display on the other hand, during nymphosis, an extreme activity of caryokinetic proliferation. Thus their number becomes quite considerable, and their size remains relatively very small in comparison to the larval cells of the corresponding organs. Fig. CLXII recapitulates these contrasts and Table A states them precisely by giving numerical dimensions.

To be sure, there are a few exceptions. Some imaginal cells are of great size, for example some nervous ganglionic cells, the cells of the rectal papillae, the nutritive cells of the large tegumentary hairs, etc. But, for these cells, the large size is one of the special characteristics of the imaginal histological differentiation. And these few exceptions do not detract from the importance of the general remark recalled above.

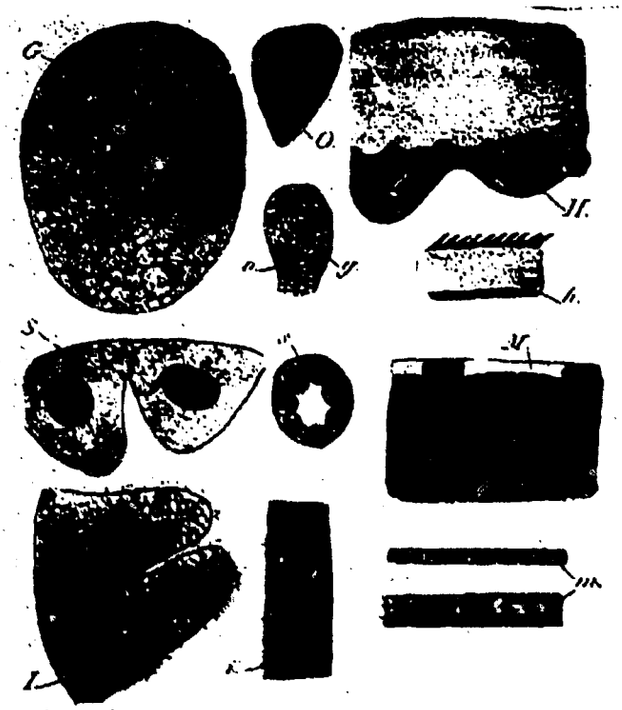

Fig. CLXII. Comparative table of the size of some larval and imaginal cells; capital letters indicate larval cells, small letters imaginal cells. G, g = fatty cells; O, o = oenocytes; H, h = hypoderm and cuticle; S, s = salivary glands; I, i = epithelium of middle intestine; M, m = muscles. (Semi-schematic). x 270.

Among the higher insects, each histological category is thus subdivided into two types, quite distinct as regards their size and often also their structure. Generally it is a question of distinct, larval or imaginal cells, which have thus followed a different route of differentiation. At other times, on the contrary, it is, as we have seen, the more plastic cells which pass from the larva into the imago; their alteration consists precisely then in the passage of the larval type into the imaginal type. The muscles furnish the best example of this, and the passage from large to small nuclei is no longer accomplished by caryokinesis as in the case of the proliferation of myoblasts, but by direct -- frequently multiple -- division; thus this is not a true multiplication

of elements but rather a subdivision, a distribution of the nuclear substance in the various regions of the cytoplasm, comparable to that often observed with the macronucleus of ciliated Infusoria.

TABLE A

Comparison of the Average Dimensions of Some Cells

Type of Cells	Dimensions of the Elements in μ	
	Larval	Imaginal
Epithelium of middle intestine.....	100-150x50	20-40x10-12
Epithelium of anterior intestine (nuclei).....	15x20	3x5
Epithelium of posterior intestine.....	50	10 (papillae excepted)
Salivary glands.....	75	20
Hypoderm.....	75-100x40-30	10-5 (hairs excepted)
Cuticle.....	85	30 (very variable)
Tracheas (nuclei in a same altered region).....	20	6-8
Adipose tissue.....	200-250	20 (syncytial)
Oenocytes.....	60-70	15x20 (binuclear)
Muscles (diameter of bundles).....	100-150 (large bundles)	10-20 (isolated fibers)
Muscular nuclei.....	10x25 (superficial)	3-5 (axial)

It is quite difficult to ascertain the causes determining these divergences of size among the larval and imaginal cells. The imaginal type where, with sizes being equal, an organ is constituted by a quite large number of cellular units, permits perhaps a more active functioning. I would willingly believe that it is the imaginal type of reduced size that is the fundamental type: the original ancestral type among the metabolic insects; and since the external forms of the larvae have coenogetic adaptations, the large size of their histological elements would likewise be a secondarily acquired characteristic and corresponding to

the fact that an as limited number of embryonic cells as possible adapt themselves to the transitory physiology of the larva. These cells are in some way sacrificed in advance; their premature differentiation arrests their reproductive power; now they are capable only of an individual growth. At the same time their so-to-speak exaggerated development momentarily inhibits that of other embryonic cells which preserve in them the hereditary imprint and will give the true insect when, on awakening from their torpor, they will be able to make themselves explicit in turn.

The organism of the perfect insect is thus constituted in its main characteristics of cells which are particular to it, which are essentially imaginal, predetermined since their embryonic origin. They are the ones forming the histoblasts, disseminated in enclaves or scattered among the larval organs, and which proliferate during nymphosis, unite and arrange into new organs. Another portion, the least specialized one of the imaginal organism originates through a modification in situ of the — also least specialized — part of the larval organism; and in these parts the anatomic elements are more or less transformed, but preserve during the entire nymphosis their character of living cells.

I will recall here the case of the epithelial cells of the posterior intestine which, by renewing themselves through caryokineses before forming the rectal papillae, eliminate at the same time balls of degeneration; and also the case of the intestinal muscles. The passage from the larval type to the imaginal type begins here by a sort of cellular autonomy. This process of rejuvenation by partial purification seems to me highly worthy of retaining one's attention.

In the imaginal histogenesis the case is either that of epigenesis or modification in situ. Berlese believed to be able to admit for the mesodermic cells the possibility of a dislocation and a migration, interposing during the nymphoses between two states, larval and imaginal, where these cells are, on the contrary, combined into tissues. This concept is only accurate for the fatty body. It is, in fact, a law which appears to be general among the metabolic insects, that the adipose cells associated in sheets in the larva liberate themselves from their mutual adherences at the start of the nymphosis and float freely in the blood; then, before the appearance of the imago they resume a new cohesion, after a mixing which has more or less displaced them. This fact is made possible by the physiological

circumstance that each of the fatty cells functions in some way for itself and is able to fulfill its role of exchanges with the blood, of accumulation or restitution of reserves, whether or not they are agglomerated with their neighbors into tissues. But among the Muscidae, even this particular case is not realized; the de-aggregation of the larval tissue which takes place at the start of the nymphosis is definitive and the cells remain isolated and floating until their final destruction, while the new coherent tissue forms from another origin.

In any case I cannot accept Berlese's opinion either for the muscles or for the imaginal fatty body, an opinion according to which their origin is the division of chromatic balls resulting from the larval muscular nuclei. A similar evolution, consisting of a genesis of new complete cells starting from exclusively nuclear substances and making their appearance, on the other hand at the interior of a phagocyte in order to complete itself in liberty outside of the latter, would shock the concepts which we believe are those best established in regard to the general processes of histology. But we are not reduced to this criticism a priori. We have seen, in fact that these opaque chromatic balls, ingested by the phagocytes are not afterwards thrown out of them; on the other hand the small discrete nucleus, the leucocytic nucleus, is the only living element, the only true nucleus of the sphere of granules; all the other chromatic balls which it may contain are always only forms of pycnotic degeneration of ingested larval nuclei. The division of these balls, far from being comparable to a multiplication of living elements leading to an imaginal histogenesis, is on the contrary only a dislocation of dead elements. Moreovsr the forms interpreted by Berlese as divisions correspond much less to a chromatolytic division of a sole nucleus than to a simultaneous or successive ingestion of several pycnotic balls by the same sphere of granule. And on the other hand it is easy enough to recognize in the embryonic histoblasts the origin of the myoblasts and of the imaginal fatty body. The role of the spheres of granules is a simple role of phagocytosis; they complete the digestion of their inclusions and disappear; often, infiltrated into various tissues in the process of growth, they no doubt furnish them with dissolved nourishments but they never personally contribute to the building of tissues.

To sum up, I believe to have justified the phagocytic interpretation against the criticisms or doubts which certain authors have recently expressed on the subject. After the

reservations which I have expressed at the very start of this paper, I would not here add the case of Muscidae to that of other insects, and to permit myself to be involved in risky generalizations. It has nevertheless been obvious that some of my current results exactly corroborate those of my previous study on the ants. I freely believe that for these common formula the extrapolation is permissible and that, with all the metabolic insects, there are present three ensembles of histological processes: total destruction of the most specialized larval elements; entirely new construction, starting from histoblasts that have remained embryonic, of the most specialized organs of the imago; and alteration in situ of the least specialized and most plastic organs and cells, capable by this relative indifference of taking a place successively in two different phases of physiological coordination. These three processes are superposed and affect each other in various degrees; and the metamorphosis is the more intense or the more moderate the more the larval organism is specialized in an aberrant manner or, on the contrary, the more it has preserved the typical ancestral constitution and can be better utilized in the nymphal building-up of the perfect insect.

Plate I.

Table of Chronological Agreement of the Principal Facts of Nymphosis in Calliphora Erythrocephala Mg.

[Translator's Note: This table consists of 11 columns. The age is entered in the first column and the corresponding events horizontally across. For the sake of simplicity each individual column is translated separately, and the sign // is used to separate one chronological entry from another.]

Column headed by Age: Pupe blanche = white pupa; heures = hours; jours = days;

Column headed by "Hystolyse Musculaire (Muscular Hystolysis)": Large Number of leucocytes. Direct divisions // The leucocytes accumulate in the vicinity of the muscles and,begin to dislocate them starting at the front and progressing toward the back // Phagocytosis almost terminated; spheres of granules still grouped at the site of the muscles //The spheres of granules disperse in the general cavity // The spheres of granules infiltrate into the salivary glands;// invade the abdominal hypoderm;// infiltrate into the abdominal larval muscles // into the imaginal hypoderm of the head, legs, wings, // into the tendons of the flight muscles // into the ovary, the composite eye, under the musculature of the imaginal maw, or the posterior intestine// Completion of the digestion of sarcolytes and // Fatty degeneration of the phagocytes.

Column headed by "Histogenese Musculaire (Muscular Histogenesis)": Caryokinetic proliferation of the myoblasts of the appendices // Myoblasts of the wing gain toward the back and surround the persisting larval muscles which have become homogeneous, // and begin to dissociate them. // The six masses of longitudinal vibrators are noted// Annexation of the myoblasts to the persisting vibrator muscles;rough tendons of flight muscles // Fusion of myoblasts of light with larval muscles completed; orientation of nuclei // Fusion of myoblasts with the abdominal muscles. Multiple divisions in the legs, dilators of the pharynx. // Fibres of legs elongate // Divisions into chaplets in the abdominal muscles, tracheoles penetrating into the sarcoplasm of the flight muscles // expansion of the abdominal insertions. Reappearance of striation.

Column headed by "Intestin Moyen (Middle Intestine):" Caryokinetic proliferation of nests of regeneration which spread to the surface of the contracted muscular sleeve // Imaginal cells spread in a single layer; reticulated tissue compressing the larval epithelium. Start of the invasion of the musculature // Imaginal epithelium constituted in cylindrical layer. Phagocytosis of the muscular tunic // Contraction of the reticulated tissue; formation of yellow body // The middle intestine takes

the shape of a large spindle // which is attenuated at its extremities // Reconstitution of the imaginal musculature // Curving into abdominal circumvolutions // The yellow body emigrates toward the base of the abdomen // Differentiation of the rounded evaginations, brush-like edge, etc.

Column headed by "Intestin Anterieur (Anterior Intestine):" Retraction of the larval maw; deployment of the valve and proliferation of the imaginal ring // Proliferation of the outlet tube toward the front; degeneration of the larval maw and esophagus // Maw completely disappeared // Devagination of the cephalic vesicle and ventral inflection of the esophagus. Installation of myoblasts around the outlet tube // Start of the evagination of the imaginal maw // Progressive alteration of the larval esophagus // Clear indication of the maw and valve // Multiple divisions in the muscles of the maw. Pedunculated maw. // Esophagus completely altered. Valve well differentiated // Folding of the wall of the maw // Final differentiation.

Column headed by "Intestin Posterieur (Posterior Intestine):"Diminution of the lumen // Deployment of the imaginal ring // Phagocytosis of the anal sphincter; start of epithelial degeneration // Reduction of the posterior intestine to an axial rectilineal tract // Alteration of the rectal bulge; crude beginning of the papillae. // Junction of the bulge and the imaginal outlet tube. Multiple muscular divisions // Folding of the wall, papillae well differentiated // Accumulation of uric meconium in the rectal bulge // Expulsion of meconium.

Column headed by "Tubes de Malpighi (Malpighian Tubes)": Progressive loss of differentiation // Start of the appearance of spheroidal concretions // Cells which have lost their differentiation, with spheroidal concretions // Progressive disappearance of concretions // Appearance of urates in the lumen // Return to differentiation, brush-like edge, etc.

Column headed by "Glandes Salivaires (Salivary Glands):" Proliferation of the imaginal ring. The larval cells, sprinkled with small fat grains, display the appearance of a secretion. // Chromatic granules at the surface of the cells // Evacuation of the balls of secretion; superficial chromatic granules // Start of the infiltration by the muscular spheres of granules // Dislocation and incorporation by the phagocytes // Dispersion of the phagocytes // Well-developed imaginal salivary glands // Final differentiation.

Column headed by "Hypoderme et Appendices (Hypoderm and Appendices):" Caryokinetic proliferation in the histoblasts and the buds of the appendices // Thoracic hypoderm recovered; degeneration and phagocytosis // Infiltration of the abdominal hypoderm // Phagocytosis progressing toward the back // Renovation completed // Imaginal hypoderm, cuticle well differentiated; hairs, etc; // Progressive coloration of the teguments.

Column headed by "Trachees (Tracheas)": Proliferation of the imaginal buds // Thrust of cephalic tracheas // Inlets in the imaginal tracheoles in growth // Contraction of the large posterior trunks into full tracts. Degeneration of these tracts // Alteration of the longitudinal thoracic trunks // Start of the dilation of the altered tracheas // Penetration of the tracheas in the flight muscles // Imaginal tracheas with irregular contours; apparatuses of occlusion of the stigmas // Distension of the vesicles.

Column headed by "Tissu Adipeux (Adipose Tissue):" Accumulation of albuminoid inclusions // Eosinophilic inclusions and pseudonuclei // Liberation of fatty cells // Phagocytosis of some cells // Well recognisable beginnings of the imaginal tissue // Formation of small sheets of fatty cells and binuclear oenocytes // Active caryokinetic proliferation of the imaginal fatty cells // Start of fat deposit // Traumatism and phagocytosis of larval cells, head and thorax// Formation of leucocytic follicles. Resorption of the inclusions and placement into circulation of urates // Start of the final phagocytic resorption.

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Explanation of Plates

Plate I: Table of Chronological Agreement of the Principal Facts of Nymphosis in Calliphora erythrocephala Mg.[Translation of Table on pp 25 - 27 of this translation].

Plate II. Muscular Hystolysis (Ferric Hematoxylin).

Fig.1. Transversal section of a muscle, showing the infiltration of leucocytes, l. which advance by following the sheets of sarcoplasm, interposed between the contractile columns. The bluish inclusions filling up the protoplasm of the leucocytes mark out their pseudopodes clearly. N, muscular nucleus in the course of pycnotic degeneration; s, sarcolemma, continuing at t into the tendon of insertion; tr, intramuscular tracheoles. 7 hours, x 600.

Fig.2. Longitudinal section of two muscles, near their insertion on a common tendon t; leucocytes begin penetrating at the level of the tendon, and from that location they insinuate themselves by lamination between the contractile columns; 7 hours, x 600.

Fig.3. A somewhat more advanced stage; the sarcolemma has disappeared; the contractile columns, detached from their tendinous insertions, take on a sinuous shape, and their detachment facilitates the more intense migration of the leucocytes. Nuclei N are in complete pycnosis. 7 hours, x 600.

Fig.4. The leucocytes begin to insinuate sharp pseudopodes in the very thickness ofthe contractile columns, particularly at the level of the thin disks, limits of the muscular compartments. sp, diffluent sarcoplasm. 7 hours. x 600.

Fig.5. Young leucocytes of a quite young pupa, showing their characteristic granules. x 880.

Fig.6. Leucocyte at the start of immigration in a muscle, containing, besides the pre-existing granules, two pink inclusions, which doubtless represent recently incorporated sarcoplasm. x 880.

Fig.7. Horse leucocyte on the track of a dislocated sarcolemma, s, and containing two pink inclusions which doubtless represent "phagocyted" portions of this sarcolemma. x 880.

Fig.8. Frontal section, perpendicular to the direction of dilator muscles of the pharynx. The most anterior ones, Md, of these muscles, where the striation and the fields of Cohnheim persist, are invaded by leucocytes and disappear through phagocytosis. The most posterior ones, Mp, much less

eosinophilic, on the contrary persist; later on they will lose their striation and will be transformed into syncytial homogeneous areas. 7 hours, x 400.

Fig.9. A leucocytic phagocyte having incorporated some fragments of these muscles. x 880.

Plate III. Muscular Hystolysis (Continued). (Ferric Hematoxylin).

Fig.10. Quite advanced dislocation of a muscle of the anterior region. Persistence of the transversal stration (disks s) and of the fibrillar structure. Beginning of incorporation of the first sarcolytes sl, torn off the contractile columns, and of larval nuclei N in pycnotic degeneration. 10 hours, x 600.

Fig.11. More enlarged detail, showing the mode of formation and incorporation of sarcolytes, due to the pseudopodes of the leucocytes. x 880.

Fig.12. Phagocytes beginning to resume a more rounded shape after having incorporated a larger number of sarcolytes or nuclei. One may see on this figure, as in the previous one, that the incorporated sarcolytes have exactly the same appearance as the muscle portions still outside the phagocytes. x 880.

Fig.13. Advanced stage of dislocation of a muscle of the anterior region. One can judge that more than half of the muscular substance has already passed into the interior of the phagocytes in the sarcolyte state. The phagocytes are sometimes fused into giant cells, or form, temporarily, multinuclear plasmodia. The not yet incorporated portions of myoplasm are notably reduced in relation to what they were in the stage of Fig.10, some fragments are even of the size of the enclosed sarcolytes. But they all preserve the same appearance, pink and striated. On the contrary, in the phagocytes, the included sarcolytes commence to take on a deep purple or bluish tint. 10 hours, x 600.

Fig.14. Three phagocytes showing the modifications of tint and structure of included sarcolytes, indices of the first stages of intracellular digestion. x 880.

Fig.15. A phagocyte where the transformation of the sarcolytes is more advanced; one may note at the same time the progressive disappearance of the orginal granulations of the leucocyte. x 880.

Fig.16. The sarcolytes have become homogeneous and bluish; the granulations have completely disappeared. It is in this state that the phagocytes or spheres of granules spread in the cavitary liquid. x 880.

Fig.17. Two muscular nuclei in pycnosis, detached before incorporation. x 800.

Fig.18. Two pycnotic nuclei simultaneously incorporated by a phagocyte. x 600.

Fig.19. Phagocytes containing pairs of pycnotic nuclei; shapes which sometimes have been erroneously taken for divisions, and whose origin is explained by the two previous figures. x 600.

Plate IV. Middle Intestine.

Fig.20. Epithelium of the middle intestine; i, initials of pockets of regeneration. These cells may be next to intraepithelial tracheoles, but have no genetic relation whatever with the matrix of these tracheoles; they are essentially epithelial cells. Young maggot, 4 mm long. x 400.

Fig.21. Intestinal epithelium of a nearly adult maggot; the larval cells are gorged with fat droplets, aligned in a radial direction, and these drops display the absorption activity of the cells; on the other hand one never observes any ball of secretion. The imaginal cells have proliferated and constitute compact nests at the base of the functional epithelium. x 400.

Fig.22. Transversal section of the middle intestine in a maggot which has just finished eating and prepares itself for nymphosis. The food has disappeared, which fact has allowed the reduction in size of this organ; the cells are still packed with fat droplets in a dense manner (freely blackened by osmic acid, these droplets have conventionally been represented in grey). The pockets of regeneration, i, appear like rounded buttons, projecting on the coelomic surface of the intestine; their most superficial cells, on the intestinal side, begin to exfoliate and emigrate by insinuating themselves at the base of the larval cells; they will constitute the origin of the reticulated tissue. x 225.

Fig.23. Longitudinal section of a portion of the intestine in a very young, still white, pupa. The reticulated tissue, r, is well indicated at the base of the larval epithelium, whose exuviation it determines; the brush-like edge still persists. The musculature is contracted into a continuous folded sleeve, at whose internal surface the imaginal pockets, i, begin to spread out; n, muscular nucleus, surrounded by a more chromatic protoplasmic region. x 225.

Fig.24. Section of a section of intestine in a pupa 20 hours old. The nests of regeneration have flowed together and are organised into a new continuous epithelial layer, e; to the exterior the larval musculature

has been dislocated and destroyed by the phagocytes; it is only represented by a mass of spheres of granules, and by the muscular cells m, originating from the old liberated nuclei; in the interior the reticulated tissue, r, has expanded its openings and resembles a loose connective network. The larval epithelium E, completely rejected, begins to degenerate; confluence of the cells, loss of the brush-like edge. etc. x 225.

Fig.25. Final state of the imaginal epithelium. Pupa 18 days old. x 880.

Plate V. Anterior Intestine.

Fig. 26. Larval maw (jabot) retracted upon itself, and showing only a single region of increased epithelium, outlining a dorsal convexity (V., Fig. XLII, j). The chitinous intima of the maw, folded upon itself, ch, is rejected into the lumen of the esophagus; the epithelium of the maw exhibits numerous forms of degeneration, d; and its cells are progressively eliminated toward the general cavity where they become the prey of phagocytes. The musculature of the maw has already disappeared to a great extent and is only represented by a mass of spheres of granules. In the lower part of the figure one can see this dislocation which continues by rupture of the sarcolemma s, and infiltration of the leucocytes l into the larval musculature. 6 hours. x 400.

Fig. 27. Degeneration of the posterior region of the esophagus, in the area where the anterior edge of the imaginal outlet tube a insinuates itself in a bevelled form under the larval cells. The cells flow together and their cytoplasm degenerates into balls d; the nuclei N are struck by chromatolysis; c, chitinous molting of the esophagus; p, stomatogastric plexus; leucocytes l are dislocated and act as phagocytes on the musculature, and absorb rejected epithelial elements. 6 hours. x 400.

Plate VI. Anterior Intestine.

Fig. 28. Degeneration and elimination, toward the general cavity, of cells of larval maw. 6 hours. x 400.

Fig.29. Imaginal outlet tube, with caryokinetic divisions * at the free surface of the epithelium; a, ring of support of the heart c. Between the deep face of the epithelium and the heart a complex tissue develops in which caryokineses are also observed. The most relaxed peripheral part of this tissue, of reticulated appearance, particularly infiltrated with spheres of granules, certainly constitutes the stomatogastric nervous plexus p; the deepest, most compact part which is confined to the epithelium, represents the imaginal myoblasts; but the limit is not decisive between these two categories of elements. M, persisting larval muscles. Below and to the left, portions of larval muscles M, lent to a neighboring section. 32 hours. x 600.

Fig.30. Folds of Imaginal maw, in the abdominal cavity; only the epithelium is convoluted, without being followed by the muscular network; spheres of granules begin to be infiltrated between the two tunics of the organ, in the depth of its folds. 13 days. x 225.

Fig.31. Differentiation of the imaginal valve. E, larval epithelium persisting in the posterior region of the esophagus; j, tube leading to the maw and continuing in the direction of the esophagus; n, portion of nervous connective tissue. 12 days, x 225.

Plate VII. Anterior and Posterior Intestines.

Fig.32. Complicated plaitings of the epithelial tunic of the maw, and penetration of spheres of granules as far as the deepest folds; the musculature m does not follow the general contour of the organ. 15 days, x 400.

Fig.33. Region of agreement between the imaginal outlet tube and the posterior ending of the esophagus; j, start of the evagination of the imaginal maw; m, myoblasts; M, larval muscles. The larval epithelium partially degenerates and is infiltrated by phagocytes which absorb its debris; in front/[illegible] to arrive also some imaginal cells, in caryokinetic proliferation *. 3 days, x 400.

Fig.34. Imaginal outlet tube and start of posterior larval intestine, TM, Malpighi tube; *, caryokineses on the surface of the imaginal epithelium; d, degeneration of the larval epithelium; M, persisting larval muscles; the whole plunged into a mass of spheres of granules. 46 hours, x 400.

Fig.35. An inlet of the posterior intestine in degeneration, in the midst of a compact mass of sphere of granules, sg, charged with muscular or epithelial debris; d, epithelium in degeneration and eliminated toward the coeloma; m, muscular cells originating from the larval musculature and which will persist by reconstituting the imaginal musculature. 46 hours, x 400.

Plate VIII. Posterior Intestine; Hypoderm; Trocheas (hemalum-eosine-aurantia).

Fig.36. Transverse section of the treat of posterior intestine in degeneration; all around, a dense accumulation of spheres of granules, often charged with sarcolytes (orange) s, and which absorb in situ the balls of cytoplasmic degeneration and the pycnotic nuclei of the epithelium (violet-ish inclusions). In their interstices the muscles are molded in the course of alteration. 4 days, x 400.

Fig.37. Analogous section at a level where the epithelial membrane is only formed of three cells, for the time being still in good condition. 4 days. x 400.

Fig.38. Degeneration and phagocytosis of the thoracic larval hypoderm, rejected in the coelome by the overlapping of the imaginal hypoderm (region h of figure LXXXV). The orange inclusions are sarcolytes carried in from the outside by the spheres of granules. Some hypodermic cells are still nearly normal; others manifestly degenerate and are resolved into balls which are then incorporated by the phagocytes. 20 hours, x 400.

Fig.39. Phagocytosis in situ of the abdominal hypodermis. Invasion by spheres of granules, eventually charged with sarcolytes s which cut up, as if by a puncher, the larval cells, and tear them off into fragments which become rounded and form violet-ish inclusions. N, "phagocyted" nucleus. 3 days, x 880.

Fig.40. Stage analogous to the previous one; young leucocytes l participate in the phagocytosis with the spheres of granules; H, two hypodermic cells detached from the surface and surrounded by phagocytes; the sphere of granule sg still contains some sarcolytes in process of digestion; the other phagocytes hardly contain anything but inclusions torn off from the hypoderm. 3 days, x 880.

Fig.41. Phagocyte that has just incorporated a hypodermic nucleus, N. x 800.

Fig. 42. Slice of a sphere of granules containing inclusions of hypodermic origin, in particular a nucleus N, whose chromatolysis begins. The leucocytic nucleus is not included in this slice. x 800.

Fig.43. Sphere of granules which has incorporated numerous pycnotic balls, originating from the abortion of imaginal hypodermic cells. These forms have sometimes been taken, erroneously, for stages of division. x 800.

Fig.44. Portion of epithelial lining of a large longitudinal tracheal trunk in a region where it collapses upon itself; ch, chitinous intima; which is crumpled and penetrates into the anfractuosities of the epithelium where it appears to be resorbed; d, inclusion coming without any doubt from this resorbed chitin. 32 hours. x 400.

Fig.45. Imaginal trachea at the base of a leg. Transversal section, showing the complication of the imaginal surface in relation to the nymphal cylindrical intima. 18 days, x 400.

Plate IX. Salivary Glands (Hemalun-eosine-aurantia).

Fig.46. Start of invasion of the salivary gland by young leucocytes, l. and by spheres of granules charged with sarcolytes, s. N, nucleus of the large salivary. 3 days, x 600.

A, detail of the protoplasmatic network, showing the chromatic granulations deposited on its openings.

Fig.47. Intensive infiltration by the spheres of granules charged with sarcolytes s; the salivary cell now only appears like the gangue of a sort of pudding; N, its nucleus; n, muscular (larval) nucleus incorporated by a sphere of granules. 3 days, x 600.

Fig.48. Cell of salivary gland infiltrated with spheres of granules which, in addition to the sarcolytes s taken from the outside, begin to exhibit rounded inclusions, reticulated or homogeneous ones whose violet color as well as structure clearly indicate that they are portions of the salivary cell itself, torn off in situ. 3 days, x 600.

Fig.49. Appearance of the ensemble of a portion of salivary gland gs, in course of dislocation and advanced phagocytosis; G, larval adipose cells; i, wall of middle intestine. 3 days, x 225.

Fig.50. Degeneration into balls of some cells in the neighborhood of the excretory tube, independent of the action of the phagocytes; l, infiltrated leucocyte; nd, nucleus in degeneration. 46 hours, x 400.

Plate X. Tracheae.

Fig.51. Terminal posterior region of the great longitudinal trunk in its preserved section; degenerations and alterations of the epithelial matrix. Further back, the large trunk is transformed into a full tract T which extends through the entire length of the abdomen up to the posterior stigma; t, nymphal tracheae of the tail of the larva; v, trachea distended by air where there is inserted also a tendon of splanchnic muscle. 46 hours, x 400.

Fig. 52. Tract in degeneration of the longitudinal trunk. 46 hours, x 400.

Fig.53. Two portions of the tract in degeneration; formation of cytoplasmic balls; chromatolysis of the nuclei; infiltration of spheres of granules; t, imaginal tracheae. 46 hours, x 400.

Fig.54. Transverse section of the tract in degeneration; invasion by the spheres of granules. 46 hours, x 400.

Fig.55. Analogous section, further back. 46 hours, x 600.

Fig.56. Alteration of the large thoracic trunk T, at the level of the mesothoracic stigma st; infiltration by spheres of granules which previously had "phagocyted" fatty cells, and which are incorporating the degenerated epithelial cells. 3 days, x 400.

Plate XI. Muscles and Adipose Tissue (hemalum-eosine-aurantia).

Fig.57. Group of imaginal cells and spheres of granules, in the posterior angle of an abdominal segment; g, fatty cells; o, oenocyte; N, larval nucleus, doubtless hypodermic, in degeneration in a phagocyte; the leucocytic nucleus is in the neighboring section. 12 days, x 880.

Fig.58. Abdominal muscle, to which some imaginal myoblasts are fusing, m. N, larval nuclei emigrated in depth; n, nuclei of fused myoblasts. 7 days, x 600.

Fig.59. Abdominal muscle, that has become homogeneous, longitudinal section; i, beginnings of adipose tissue (imaginal); m, myoblasts; N larval nuclei; n, imaginal nuclei; sg, spheres of granules charged with sarcolytes, penetrating into the muscular syncytium, the hypoderm; t, tendon of insertion of muscle. 7 days, x 600.

Fig.60. Transverse section of a cephalic imaginal muscle fiber. 18 days, x 880.

Fig.61. Transverse sections of muscle fibers of legs, still imperfectly developed.17 days, x 880.

Fig.62. Imaginal sheet molded on a sphere of granules; the leucocytic nucleus is in the neighboring section; gm imaginal adipose syncytium; o, imaginal oenocyte; N, phagocyted larval nucleus in degeneration. 14 days, x 880.

Fig.63. Thoracic imaginal adipose tissue g, in contact with the hypoderm; ph, giant cells formed by the fusion of spheres of granules sg, which have digested their enclaves and only contain fat. 17 days, x 880.

Fig.64. Caryokinetic proliferation of fatty cells in an imaginal sheet of the abdomen. 14 days, x 880.

Fig.65. Imaginal sheet beginning to be charged with fat; in the vicinity spheres of granules completing the digestion of their inclusions. 17 days, x 880.

Fig.66. Imaginal sheet molded on a sphere of granules packed with sarcolytes. 15 days, x 880.

Fig.67. Altered abdominal muscle, containing in its axis three spheres of granules sg, completing the digestion of their sarcolytes. N, larval nucleus; n, imaginal nucleus. The section shaves through at the neighborhood of the insertion; it also does not contain the small nuclei in chaplets which occupy the axis of/contractile columns. 17 days, x 600.

Fig.68. Cephalic imaginal adipose tissue. 15 days. x 880.

Plate XIX. Muscular Histogenesis

Fig. 69. Transverse section of the rough piece of the longitudinal vibrator muscles on the left side; massive proliferation of myoblasts in the midst of which are immersed the six syncytial regions deriving from larval muscles; the latter, in which one still finds large original nuclei, increase by apposition of myoblasts. 5 days, x 225.

Fig.70. Detail of the preceding figure, showing the caryokinetic multiplication of myoblasts * and their progressive fusion with the larval syncytial mass. 5 days, x 1100.

Fig.71. More advanced stage of the rough muscular piece; the myoblasts are almost all fused with the syncytial masses. In the latter the small nuclei are oriented on the prismatic surfaces which exhibit in section a pentagonal mosaical design. 6 days, x 225.

Fig.72. Transverse section of a persisting abdominal muscle, transformed into a homogeneous mass; imaginal myoblasts m are fusing with it; N, larval nucleus emigrated to the depth. 7 days, x 880.

Fig.73. Histogenesis of a dilator muscle of the pharynx; caryokinetic proliferation of myoblasts *; multiple nuclear divisions in the myoblasts which have become fusiform; d, mass in chromatolytic degeneration. 7 days, x 880.

Fig.74. Two vicinal muscular bundles of the dilator muscles of the pharynx (fronto-pharyngeal). One of them derives manifestly from the alteration of a larval fibre; N, larval nucleus, n, imaginal nuclei deriving from the fusion of the myoblasts and multiplying by direct divisions in chaplets. The other displays multiple nuclear divisions, k, and doubtless originates exclusively from myoblasts. 7 days, x 600.

Plate XIII. Larval Adipose Tissue (Hemalum-eosine-aurantia).

Fig.75. Adipose tissue of a rather old maggot; beginning of the appearance of albuminoids. x 400.

Fig.76. Fatty cell of a young pupa; inclusions with / pseudonuclei. 7 hours, x 400.

Fig.77. Fatty cephalic cell of a pupa of 5 days; inclusions with diverse affinities; the polarised distribution of the inclusions is not a general fact. 5 days, x 400.

Fig.78. Larval fatty cell in the abdomen of an imago which has just appeared; large eosinophilic inclusions without pseudonuclei. x 400.

Fig.79. Larval cell in the process of resorbing its albuminoid inclusions, and whose size is already notably reduced. 17 days, x 400.

Fig.80. Cell of even more reduced size. 17 days. x 400.

Fig.81. Larval thoracic cell; the albuminoid inclusions are to a great part resorbed, and the urates (pseudonuclei) are placed back into circulation; leucocytes l begin to surround the cell and to form a follicle to the latter. These leucocytes appear to be spheres of granules that have completed the digestion of their inclusions. 18 days, x 880.

Fig.82. Cell freed of its urates and resorbing its albuminoid inclusions; size already markedly reduced; l, leucocytic follicle. Abdomen of an imago which has just appeared. Smear. x 880.

Fig.83. Cell where the resorption is still more advanced, size even more reduced. Abdomen of an imago that has just appeared. Smear. x 880.

Fig.84. Cell where all inclusions have disappeared. Size reduced to the minimum; the leucocytic follice is complete (l), and the nucleus of the cell begins to degenerate. Image taken in liberty. x 880.

Fig.85. Group of three larval cells in the midst of sheets of imaginal tissue. In one, the nucleus has not yet degenerated; in the other, it is resolved into a star-shaped chromatolytic mass; the third is completely dislocated by the leucocytes of the old follice ph, which penetrate into its interior and absorb some chromatolytic balls. Image taken in liberty. x 880.

Plate XIV. Adipose Tissue.

Fig.86. Larval cell taken between muscular fibers f, perpendicular to the plane of the figure and bursting under their pressure; at the periphery leucocytes l, incorporating their debris. Head. 15 days, x 600.

Fig. 87. Larval cell laminated between muscular fibres and infiltrated by phagocytes; the nucleus displays a manifest chromatolysis. Head, x 600.

Fig.88. Larval cell G, taken between a muscular fibre and the imaginal hypoderm h; it begins to be attacked at its periphery by phagocytes; g, sheet of imaginal adipose tissue, deprived of oenocytes. Thorax, 15 days, x 600.

Fig.89. Larval cell laminated between muscular fibres and infiltrated

by phagocytes 1; the nucleus does not yet exhibit chromatolysis. Head, 15 days. x 600.

Fig.90. Larval cell attacked at its periphery by phagocytes; nucleus still normal. Head, 15 days. x 600.

Fig.91. Cephalic imaginal adipose tissue, 18 days. x 880.

Plate XV. Adipose Tissue and Muscular Insertions

Fig. 92. Thoracic imaginal adipose tissue a; p, plasmodium of phagocytes having digested their inclusions. 17 days. x 880.

Fig.93. Abnormal larval adipose cell with four nuclei. Aged maggot. x 225.

Fig.94. Sheets of imaginal adipose tissue g, insinuated between large fatty larval cells still persisting, G; o, oenocytes of imago; p, hair. Tracheas begin to penetrate into the imaginal adipose tissue; the leucocytes begin to organise themselves into a follicle around the larval cells, G. Abdomen, 18 days, x 600.

Fig.95. Insertion of longitudinal vibrator muscles on the thoracic teguments. Hypodermic cells drawn out into long tracts between which larg larval cells and spheres of granules insinuate themselves; t, tracheas comprised between the muscular masses; in these latter ones one will note the persistence of larval muscular nuclei. 13 days, x 225.

Fig.96. Insertion of thoracic imaginal muscles on an apodeme; filiform tendons constituted by hypodermic cells h, disproportionately elongated. 17 days. x 600.

Plate XVI. Various Tissues (Borrel's liquid, magenta, picro indigo-carmine. The color of the protoplasms has sometimes been slightly transposed in order to facilitate lithographic reproduction).

Fig.97. Wall of larval maw (jabot) and its contents where bacteria swarm. c, chitin; e, epithelium; m, muscle; s, ingested muscular debris. Maggot 4 mm long. x 880.

Fig.98. Two adipose cells of a quite young larva. x 880.

Fig.99. Adipose cell of a maggot 4 mm long. x 880.

Fig.100. Two spheres of granules containing at the same time quite voluminous sarcolytes (yellow), and fat droplets. Old pupa; x 600.

Fig.101. Two spheres of granules more advanced in their digestion;

one still contains two small sarcolytic inclusions, the other no longer contains anything but fat. x 600.

Fig. 102. Isolated insertion of a larval muscle on the hypoderm. The sarcolemma of the muscle s is continued directly with basal b of hypoderm H. The hypodermic tonofibrils are prolonged by a convergent cone of striae, stratified throughout the entire acidophilic chitin, up to the chromatic chitin. Adult maggot, x 880.

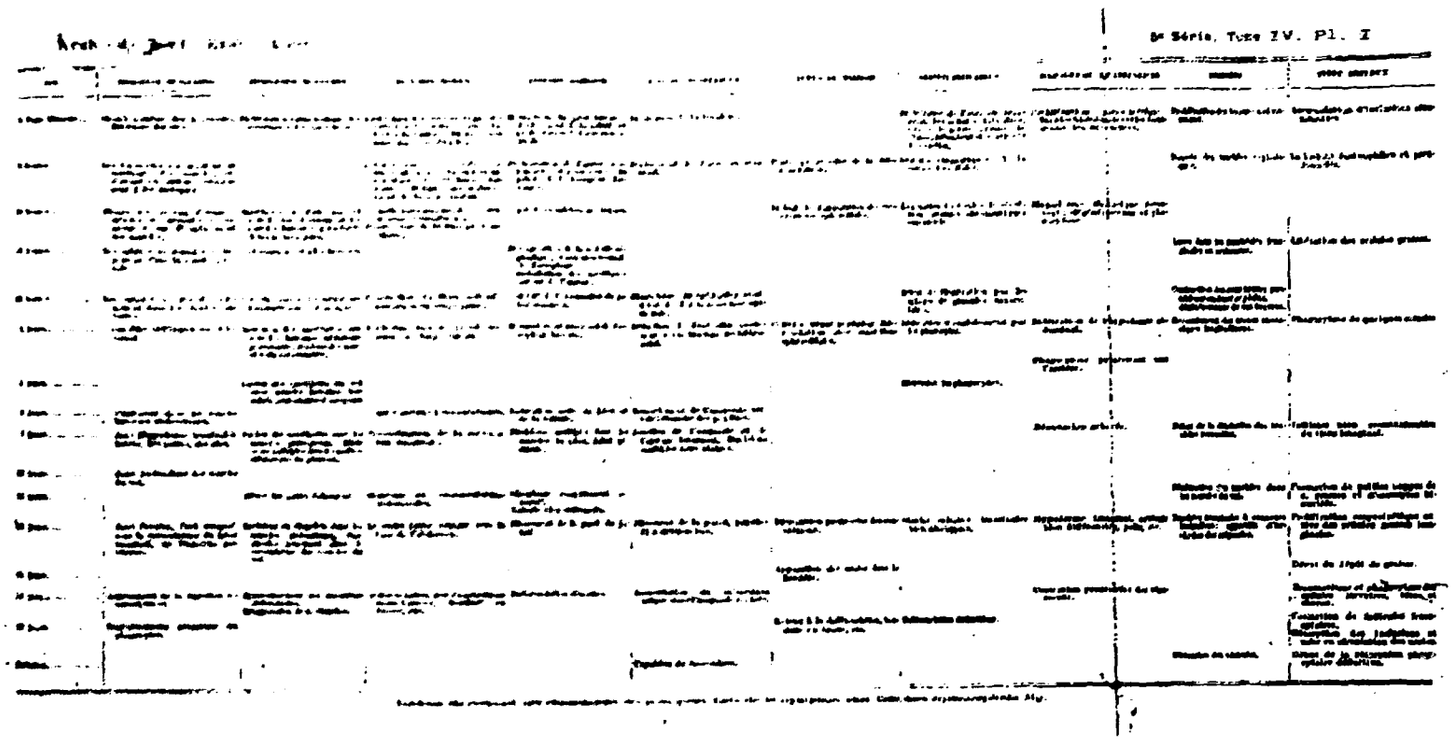
Fig.103. Imaginal adipose tissue and oenocytes. Abdomen. Imago at the moment of eclosion. x 600.

Fig. 104. Imaginal adipose tissue and oenocytes. m, ventral subtegumentary muscles. Abdomen. Imago after hibernation. x 890.

Fig.105. Cephalic Imaginal adipose tissue. Imago, x 600.

Fig. 106. Imaginal adipose tisuue and oenocytes in a female, exhausted at the time of egg laying. Total disappearance of fatty reserves. x 400.

Fig.107. Small pericardiac cells with inclusions which seem to be bacteria, despite the fact that the cells are generally considered incapable of phagocytosis. A quite young maggot: smear. x 600.



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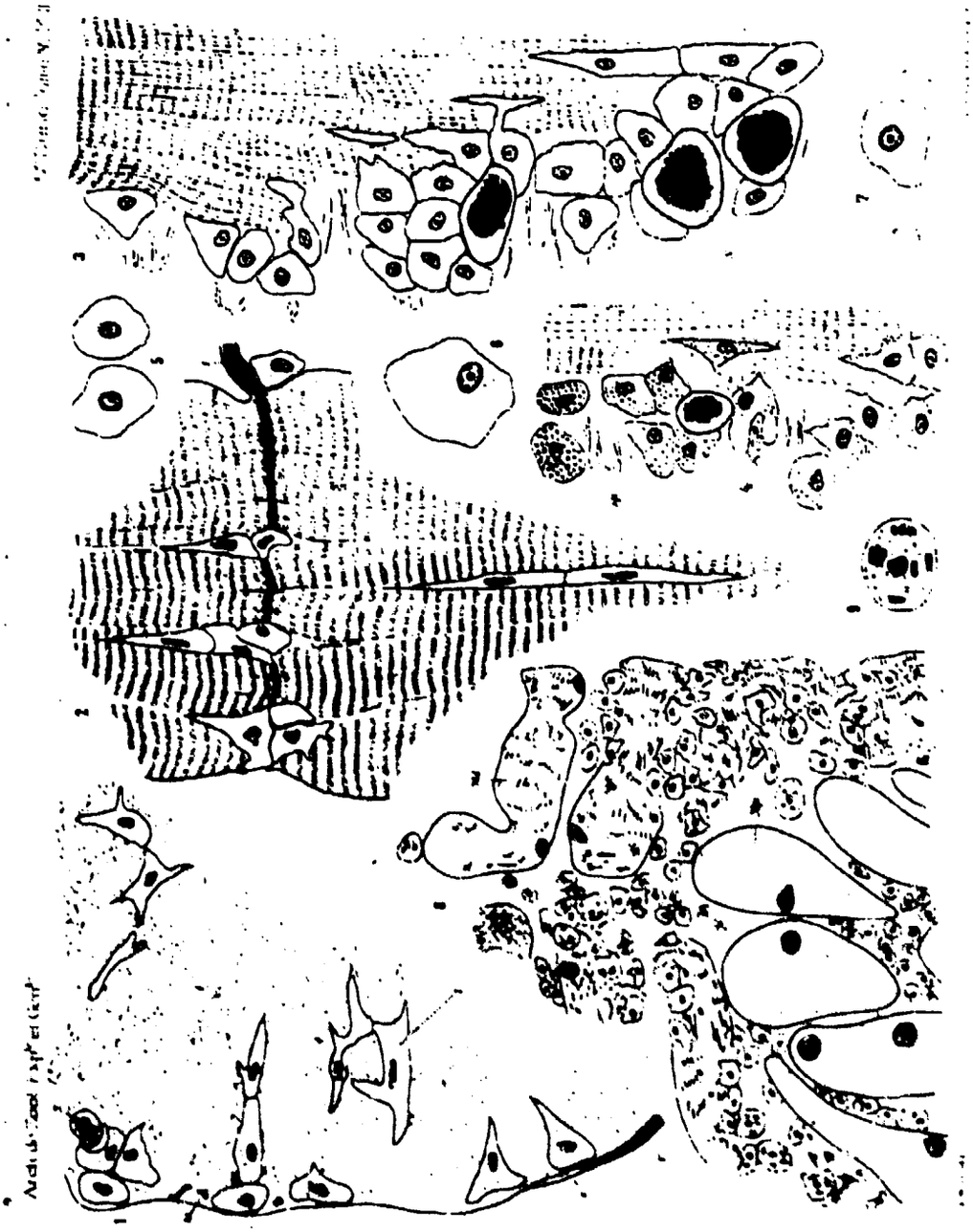

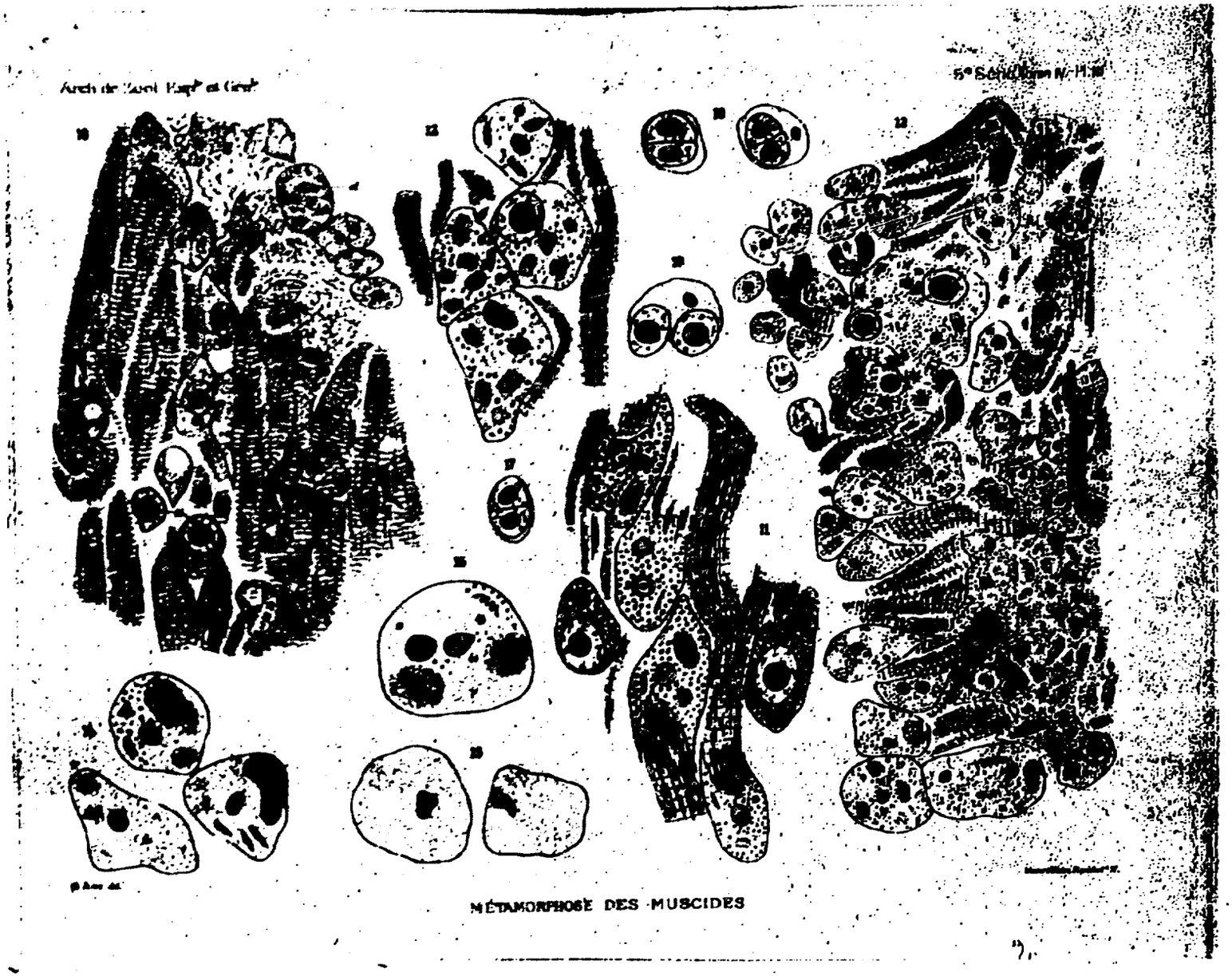

MÉTAMORPHOSE DES MUSCIDES

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